Suzaku Observations of Supergiant X-ray Binaries

Arash Bodaghee  SSL - UC Berkeley
HIGH-MASS X-RAY BINARIES

BEXB
Be X-ray Binary

light curve
X-ray luminosity (erg s\(^{-1}\))
10\(^{31}\)–10\(^{35}\)
on-timescale
days/weeks
off-timescale
months/years
spin period (s)
1–1000
orbital period (d)
10–1000
prototype
V 0332+53
High-Mass X-ray Binaries

- **BEXB**
  - Be X-ray Binary
  - 

- **SGXB**
  - Supergiant X-ray Binary

- **Light curve**
- **X-ray luminosity (erg s⁻¹)**: \(10^{31} - 10^{35}\)
- **On-timescale**: days/weeks
- **Off-timescale**: months/years
- **Spin period (s)**
  - 1—1000
- **Orbital period (d)**
  - 10—1000
- **Prototype**
  - V 0332+53

- **10^{35} - 10^{37}**
- **Quasi-continuously**
- **Minutes**
- **100—5000**
- **1—50**
- **Vela X-1**
High-Mass X-ray Binaries

- **BEXB**: Be X-ray Binary
  - Light curve: 10^{31}–10^{35} erg s^{-1}
  - On-timescale: days/weeks
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  - Spin period (s): 1–1000
  - Orbital period (d): 10–1000
  - Prototype: V 0332+53

- **SFXT**: Supergiant Fast X-ray Transient
  - Light curve: 10^{32}–10^{36} erg s^{-1}
  - On-timescale: hours/days
  - Off-timescale: weeks/months
  - Spin period (s): 10–500
  - Orbital period (d): 10–200
  - Prototype: XTE J1739–302

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  - Light curve: 10^{35}–10^{37} erg s^{-1}
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High-Mass X-ray Binaries

- BEXB: Be X-ray Binary
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near a dozen new SGXBs/SFXTs have been observed by Suzaku
these are in addition to the “classical” systems:
4U 1907+09: Rivers et al. 2010; talk by K. Pottschmidt
4U 2206+54: Finger et al. 2010
AX J1841.0–0536: poster by K. Kawabata
Cyg X-1: Makishima et al. 2008; Nowak et al. 2011; talks by S. Yamada and S. Torii
GX 301–2: talk by K. Pottschmidt
LMC X-4: Hung et al. 2010
LS 5039: Kishishita et al. 2009; Takahashi et al. 2009; Yamaguchi et al. 2010
SFXT flaring mechanisms: poster by S. Sasano
Vela X-1: poster by H. Odaka
probable NS orbiting SG B[e] d ~ 1.6 kpc absorbed SGXB

97 ks Suzaku obs.

huge absorption ($>10^{24}$ cm$^{-2}$)

Barragàn et al. 2009
Suzaku broadband observation of IGR J16318–4848

probable NS orbiting SG B[e] d ~ 1.6 kpc absorbed SGXB

97 ks Suzaku obs.

huge absorption (>10^{24} \text{ cm}^{-2})
iron line complex

Barragàn et al. 2009
probable NS orbiting O9Ib SG
$P_{\text{orb}} = 4.9$ d
$d \sim 3.6$ kpc
SFXT archetype

240 ks Suzaku obs.

$10^{-13} - 10^{-9}$ ergs/cm$^2$/s

Rampy et al. 2009
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240 ks Suzaku obs.

$10^{-13} - 10^{-9}$ ergs/cm$^2$/s

spectrum hardens w/ L variable absorption

Rampy et al. 2009
Suzaku observes four obscured SGXBs/SFXTs

High absorption (>10^{23} \text{ cm}^{-2})

Stringent iron line u.l. for all four

P_{\text{spin}} = 1056 \text{ s in Swift J2000.6+3210}

Morris et al. 2009
Suzaku spots IGR J08408–4503 in a low-activity state

probable NS orbiting O8.5Ib SG d ~ 3 kpc $P_{\text{orb}} = 35 \text{ d}$?

SFXT

67 ks Suzaku obs.

$L = 4 \times 10^{32} \text{ ergs/s (0.5–10 keV)}$

$L < 6 \times 10^{33} \text{ ergs/s (15–40 keV)}$

signs of accretion even at such low luminosities

Sidoli et al. 2010
Suzaku sees micro flares from IGR J17391–3021

probable NS orbiting SG
d ~ 2.7 kpc
SFXT archetype

37 ks Suzaku obs.

low-intensity state punctuated by micro flares (most common state)

Bodaghee et al. 2011


Suzaku sees micro flares from IGR J17391–3021

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37 ks Suzaku obs.

low-intensity state punctuated by micro flares (most common state)

variable absorption (×2—10) (accretion of obscuring clumps)

Bodaghee et al. 2011

<table>
<thead>
<tr>
<th>epoch</th>
<th>( N_H ) ( (10^{22} \text{ cm}^{-2}) )</th>
<th>( \Gamma )</th>
<th>unabs ( L_{0.5-10 \text{ keV}} ) ( (\text{erg s}^{-1}) )</th>
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<tbody>
<tr>
<td>quiescence</td>
<td>1.0±0.6</td>
<td>1.0±0.3</td>
<td>1×10^{33}</td>
</tr>
<tr>
<td>low state</td>
<td>4.1±0.5</td>
<td>1.5±0.1</td>
<td>7×10^{33}</td>
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Suzaku broadband Spectrum of IGR J16207–5129

probable NS orbiting OB SG
d ~ 6 kpc
absorbed SGXB

80 ks Suzaku obs.

high absorption (>10^{23} \text{ cm}^{-2})
iron line
$E_{\text{cut}}$ established: ~19 keV
typical of wind-fed XRP

$E_{\text{cut}}$ from XIS/HXD fits of others:
IGR J16318–4848: ~20 keV (B09)
IGR J16493–4348: ~18 keV (M09)
IGR J17544–2619: ~11 keV (R09)

Bodaghee et al. 2010
Did Suzaku capture IGR J16207–5129 in eclipse?

provable NS
orbiting OB SG
d ~ 6 kpc
absorbed SGXB

80 ks Suzaku obs.
eclipse?
\( F_{\text{min}} = 4 \times 10^{-12} \text{ erg/cm}^2/\text{s} \)
(>12 ks: lower/longer than XMM)

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N_H does not vary
(i.e. not an occulting clump; and not photo-ionization)

Bodaghee et al. 2010

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<tr>
<td>02a</td>
<td>19 \pm 1</td>
<td>1.3 \pm 0.1</td>
<td>2 \times 10^{35}</td>
</tr>
<tr>
<td>02b</td>
<td>19 \pm 5</td>
<td>1.5 \pm 0.4</td>
<td>6 \times 10^{34}</td>
</tr>
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\( N_H \) does not vary
(i.e. not an occulting clump; and not photo-ionization)

\( P_{\text{orb}} = 4-9 \text{ d} \)
i > 55°

Bodaghee et al. 2010
Suzaku will observe an orbit of IGR J16479–4514

- probable NS orbiting O9.5Iab SG
- $d \sim 3$ kpc
- $P_{\text{orb}} = 3.3$ d
- high activity cycle
- SFXT (intermediate?)

150 ks Suzaku obs. at various phases including eclipse

Objectives:
1) test SFXT emission models
2) establish nature of CO
3) probe its environment

(circa 8-9/2011 or 2-3/2012: PPI Sidoli; PI Bodaghee)
Conclusions & Perspectives

Suzaku's sensitivity and broad X-ray bandpass (0.5—100 keV) makes it well-suited for follow-up studies of SGXBs/SFXTs:

- Spectral evolution ($N_H$, $\Gamma$) during quiescence, low-activity states, and outbursts

- Establish $E_{\text{cut}}$ and possibly detect cyclotron absorption lines (c.f. talk by K. Pottschmidt)

- Find $P_{\text{spin}}$ for long-period pulsars
Conclusions & Perspectives

Our upcoming orbital analysis of IGR J16479–4514 will help shed light on SFXT emission mechanisms and the SFXT-SGXB connection.

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